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Industrial Demand Module

The NEMS Industrial Demand Module estimates energy consumption by energy source (fuels and feedstocks) for 15 manufacturing and 6 nonmanufacturing industries. The manufacturing industries are further subdivided into the energy-intensive manufacturing industries and nonenergy-intensive manufacturing industries (Table 6.1). The manufacturing industries are modeled through the use of a detailed process flow or end use accounting procedure, whereas the nonmanufacturing industries are modeled with substantially less detail. The petroleum refining industry is not included in the industrial module, as it is simulated separately in the Petroleum Market Module of NEMS. The Industrial Demand Module calculates energy consumption for the four Census Regions (see Figure 5) and disaggregates the energy consumption to the nine Census Divisions based on fixed shares from the State Energy Data System[1].

Table 6.1. Industry Categories

Energy-Intensive Manufacturing		Nonenergy-Intensive Manufacturing		Nonmanufacturing Industries	
Food Products	(NAICS 311)	Metal-Based Durables		Agricultural Production -Crops	(NAICS 111)
		Fabricated Metal Products	(NAICS 332)		
		Machinery	(NAICS 333)		
		Computer and Electronic Products	(NAICS 334)		
		Electrical Equipment	(NAICS 335)		
		Transportation Equipment	(NAICS 336)		
Paper and Allied Products	(NAICS 322)	Other Non-Intensive Manufacturing		Other Agriculture Including Livestock	(NAICS 112-115)
		Wood Products	(NAICS 321)		
		Plastic Products	(NAICS 326)		
		Balance of Manufacturing	(all remaining NAICS)		
Bulk Chemicals				Coal Mining	(NAICS 2121)
Inorganic	(NAICS 32512 to 32518)				
Organic	(NAICS 32511, 32519)				
Resins	(NAICS 3252)				
Agricultural	(NAICS 3253				
Glass and Glass Products	(NAICS 3272)			Oil and Gas Extraction	(NAICS 211)
Cement	(NAICS 32731)			Metal and Other Nonmetallic Mining	(NAICS 2122-2123)
Iron and Steel	(NAICS 3311-3312)			Construction	(NAICS 233-235)
Aluminum	(NAICS 3313)				

NAICS = North American Industry Classification System.

Source: Office of Management and Budget, North American Industry Classification System (NAICS) - United States (Springfield, VA, National Technical Information Service).

The energy-intensive industries (food products, paper and allied products, bulk chemicals, glass and glass products, cement, iron and steel, and aluminum) are modeled in considerable detail. Each industry is modeled as three separate but interrelated components consisting of the Process Assembly (PA) Component, the Buildings Component (BLD), and the Boiler/Steam/Cogeneration (BSC) Component. The BSC Component satisfies the steam demand from the PA and BLD Components. In some industries, the PA Component produces byproducts that are consumed in the BSC Component. For the manufacturing industries, the PA Component is separated into the major production processes or end uses.

Petroleum refining (NAICS 32411) is modeled in detail in the Petroleum Market Module of NEMS, and the projected energy consumption is included in the manufacturing total. Projections of refining energy use, and lease and plant fuel and fuels consumed in cogeneration in the oil and gas extraction industry (NAICS 211) are exogenous to the Industrial Demand Module, but endogenous to the NEMS modeling system.

Key Assumptions

The NEMS Industrial Demand Module primarily uses a bottom-up process modeling approach. An energy accounting framework traces energy flows from fuels to the industry's output. An important assumption in the development of this system is the use of 2002 baseline Unit Energy Consumption (UEC) estimates based on analysis of the Manufacturing Energy Consumption Survey (MECS) 2002.[2] The UECs represent the energy required to produce one unit of the industry's output. The output may be defined in terms of physical units (e.g., tons of steel) or in terms of the dollar value of shipments.

The industrial module depicts the manufacturing industries (apart from petroleum refining) with a detailed process flow or end use approach. The dominant process technologies are characterized by a combination of unit energy consumption estimates and "technology possibility curves." The technology possibility curve is an exponential growth trend corresponding to a given average annual growth rate, or technology possibility coefficient (TPC). The TPC defines the assumed average annual growth rate of the energy intensity of a process step or an energy end use. The TPCs for new and existing plants vary by industry and process. These assumed rates were developed using professional engineering judgments regarding the energy characteristics, year of availability, and rate of market adoption of new process technologies.

Process/Assembly Component

The PA Component models each major manufacturing production step or end use for the manufacturing industries. The throughput production for each process step is computed, as well as the energy required to produce it. The amount of energy to produce a unit of output is defined as the unit energy coefficient (UEC), another term for the energy intensity of the process.

The module distinguishes the UECs by three vintages of capital stock. The amount of energy consumption reflects the assumption that new vintage stock will consist of state-of-the-art technologies that are more energy efficient than the average efficiency of the existing capital stock. Consequently, the amount of energy required to produce a unit of output using new capital stock is less than that required by the existing capital stock. Capital stock is grouped into three vintages: old, middle, and new. The old vintage consists of capital existing in 2002 and surviving after adjusting for assumed retirements each year (Table 6.2). New production capacity is assumed to be added in a given projection year such that sufficient surviving and new capacity is available to meet the level of an industry's output as determined in the NEMS Regional Macroeconomic Module. Middle vintage capital is that which is added after 2002 up through the year prior to the current projection year.

To simulate technological progress and adoption of more efficient energy technologies, the UECs are adjusted each projection year based on the assumed TPC for each step. The TPCs are derived from assumptions about the relative energy intensity (REI) of productive capacity by vintage (new capacity relative to existing stock in a given year) or over time (new or surviving capacity in 2030 relative to the 2002 stock) (Table 6.3). For example, state-of-the-art additions to mechanical pulping capacity in 2002 are assumed to require only 81.6 percent as

Table 6.2. Retirement Rates

Industry	Retirement Rate (percent)	Industry	Retirement Rate (percent)
Food Products	1.7	Glass and Glass Products	1.3
Pulp and Paper	2.3	Cement	1.2
Bulk Chemicals	1.7	Aluminum	
Iron & Steel		Metal-Based Durables	1.3
Blast Furnace and Basic Stell Products	1.5	Other Non-Intensive Manufacturing	1.3
Electric Arc Furnace	1.5		
Coke Ovens	2.5		
Other Stell	2.9		

Note: Except for the Blast Furnace and Basic Steel Products Industry, the retirement rate is the same for each process step or end-use within an industry.

Source: Energy Information Administration, *Model Documentation Report: Industrial Sector Demand Module of the National Energy Modeling System*, DOE/EIA-MO64(2008), (Washington, DC, 2008).

much energy as does the average existing plant, so the REI for new capacity in 2002 is 0.816 (see Table 6.3). Over time, the UECs for new capacity are assumed to improve, and the rate of improvement is given by the TPC. The UECs of the surviving 2002 capital stock are also assumed to decrease over time, but not as rapidly as for new capital stock. For example, with mechanical pulping, the TPC for new facilities is -0.010, while the TPC for existing facilities is -0.007. Also provided in Table 6.3 are alternative assumptions used to reflect a more optimistic, “high tech” case.

The concepts of REI and TPCs are a means of embodying assumptions regarding new technology adoption in the manufacturing industry and the associated increased energy efficiency of capital without characterizing individual technologies in detail. The approach reflects the assumption that industrial plants will increase in energy efficiency as owners replace old equipment with new, more efficient equipment, add new capacity, or upgrade their energy management practices. The reasons for the increased efficiency are not likely to be directly attributable to technology choice decisions, changing energy prices, or other factors readily subject to modeling. Instead, the module uses the REI and TPC concepts to characterize efficiency trends for bundles of technologies available for major process steps or end use.

One exception to the general approach in the PA component is for electric motor technology choice implemented for 9 industries to simulate their electric machine drive energy end use. Machine drive electricity consumption in the food industry, the bulk chemicals industry, the five metal-based durables industries, and the three non-intensive manufacturing industries is calculated by a motor stock model. The beginning stock of motors is modified over the projection horizon as motors are added to accommodate growth in shipments for each sector, as motors are retired and replaced, and as failed motors are rewound. When an old motor fails, an economic choice is made on whether to repair or replace the motor. When a new motor is added, either to accommodate growth or as a replacement, the motor must meet the premium efficiency standard minimum for efficiency or a premium efficiency motor. Table 6.4 provides the beginning stock efficiency for seven motor size groups in each of the four industries, as well as efficiencies for EPACT minimum and premium motors.[3] As the motor stock changes over the projection horizon, the overall efficiency of the motor population changes as well.

Table 6.3. Coefficients for Technology Possibility Curve for all Industrial Scenarios (applies to all fuels unless specified)

	Existing Facilities				New Facilities				
Industry/Process Unit	Reference REI 2030[1]	HighTech REI 2030[1]	Reference TPC[2](%)	High Tech TPC[2] (%)	REI 2002[3]	Reference REI2030[4]	High Tech REI2030[4]	Reference TPC[2]	High Tech TPC[2] (%)
Food Products									
Process Heating	0.900	0.890	-0.376	-0.414	0.900	0.800	0.781	-0.420	-0.504
Process Heating-Steam	0.810	0.792	-0.751	-0.828	0.900	0.711	0.678	-0.840	-1.007
Process Cooling-Electricity	0.875	0.863	-0.476	-0.524	0.850	0.750	0.731	-0.446	-0.535
Process Cooling-Natural Gas	0.900	0.890	-0.376	-0.414	0.900	0.800	0.781	-0.420	-0.504
Other-Electricity	0.914	0.906	-0.321	-0.353	0.915	0.810	0.790	-0.434	-0.521
Other-Natural Gas	0.900	0.890	-0.376	-0.414	0.900	0.800	0.781	-0.420	-0.504
Paper & Allied Products									
Wood Preparation	0.792	0.747	-0.831	-1.038	0.882	0.701	0.532	-0.818	-1.791
Waste Pulping-Electricity	0.936	0.898	-0.236	-0.382	0.936	0.936	0.800	-0.000	-0.559
Waste Pulping-Steam	0.876	0.898	-0.472	-0.382	0.936	0.936	0.800	-0.000	-0.559
Mechanical Pulping-Electricity	0.816	0.771	-0.724	-0.925	0.931	0.701	0.580	-0.007	-1.673
Mechanical Pulping-Steam	0.665	0.771	-1.448	-0.925	0.931	0.527	0.580	-2.014	-1.673
Semi-Chemical-Electricity	0.954	0.948	-0.168	-0.191	0.971	0.937	0.777	-0.126	-0.792
Semi-Chemical-Steam	0.910	0.948	-0.335	-0.191	0.971	0.905	0.777	-0.253	-0.792
Kraft, Sulfite, Misc. Chemicals	0.870	0.827	-0.494	-0.675	0.914	0.827	0.549	-0356	-1.806
Kraft, Sulfite, Misc. Chemicals-Steam	0.757	0.827	-0.989	-0.675	0.914	0.748	0.549	-0.712	-1.806
Bleaching-Electricity	0.798	0.758	-0.801	-0.986	0.878	0.719	0.627	-0713	-1.196
Bleaching-Steam	0.636	0.758	-1.601	-0.986	0.878	0.587	0.627	-1.426	-1.196
Paper Making	0.869	0.766	-0.502	-0.949	0.885	0.852	0.451	-0.137	-2.380
Paper Making-Steam	0.965	0.766	-1.004	-0.949	0.885	0.820	0.451	-0.273	-2.380
Bulk Chemicals									
Process Heating	0.900	0.890	-0.376	-0.417	0.900	0.800	0.781	-0.420	-0.503
Process Heating-Steam	0.655	0.624	-1.508	-1.668	0.720	0.448	0.407	-1.679	-2.014
Process Heating-Natural Gas	0.810	0.791	-0.751	-0.834	0.720	0.569	0.542	-0.840	-1.007
Process Cooling-Electricity	0.875	0.862	-0.476	-0.528	0.850	0.750	0.731	-0.446	-0.535
Process Cooling-Natural Gas	0.900	0.890	-0.376	-0.417	0.900	0.800	0.781	-0.420	-0.503
Electro-Chemical	0.980	0.978	-0.072	-0.080	0.950	0.850	0.831	-0.396	-0.476
Other	0.900	0.890	-0.376	-0.417	0.900	0.800	0.781	-0.420	-0.503
Other-Electricity	0.914	0.905	-0.321	-0.356	0.915	0.810	0.790	-0.434	-0.521
Other-Natural Gas	0.810	0.791	-0.751	-0.834	0.720	0.569	0.542	-0.840	-1.007
Glass & Glass Products[5]									
Batch Preparation-Electricity	0,941	0.941	-0.217	-0.217	0.882	0.882	0.819	0.000	-0.264
Melting/Refining	0.934	0.822	-0.424	-0.700	0.900	0.868	0.449	-0.129	-2.453
Melting/Refining-Steam	0.872	0.822	-0.487	-0.700	0.900	0.837	0.449	-0.258	-2.453
Forming	0.984	0.965	-0.058	-0.129	0.982	0.968	0.826	-0.050	-0.614
Forming-Steam	0.968	0.965	-0.115	-0.129	0.982	0.955	0.826	-0.100	-0.614
Post-Forming	0.977	0.971	-0.081	-0.107	0.968	0.955	0.865	-0.047	-0.398
Post-Forming-Steam	0.955	0.971	-0.162	-0.107	0.968	0.943	0.865	-0.093	-0.398
Cement									
Dry Process	0.905	0.800	-0.356	-0.794	0.900	0.810	0.531	-0.376	-1.869
Wet Process[6]	0.951	0.894	-0.178	-0.398	NA	NA	NA	NA	NA
Wet Process-Steam[6]	0.905	0.850	-0.356	-0.579	NA	NA	NA	NA	NA
Finish Grinding-Electricity	0.975	0.850	-0.090	-0.579	0.950	0.950	0.600	0.000	-1.628
Iron and Steel									
Coke Oven[6]	0.935	0.845	-0.242	-0.600	0.902	0.869	0.637	-0.133	-1.235
Coke Oven-Steam[6]	0.873	0.845	-0.483	-0.600	0.902	0.837	0.637	-0.266	-1.235
BF/BOF	0.994	0.950	-0.023	-0.183	0.987	0.987	0.785	0.000	-0.812
BF/BOF-Steam	0.987	0.950	-0.047	-0.183	0.987	0.987	0.785	0.000	-0.812
EAF	0.925	0.845	-0.280	-0.600	0.990	0.849	0.655	-0.547	-1.463
Ingot Casting/Primary Rolling[6]	1.000	1.000	0.000	0.000	NA	NA	NA	NA	NA
Continuous Casting[7]	1.000	1.000	0.000	0.000	1.000	1.000	1.000	0.000	0.000

Table 6.3. Coefficients for Technology Possibility Curve for all Industrial Scenarios (applies to all fuels unless specified) (continued)

	Existing Facilities				New Facilities				
Industry/Process Unit	Reference REI 2030[1]	Reference REI 2030[1]	High Tech REI20301[1]	Reference TPC[2] (%)	REI 2002[3]	Reference REI2030[4]	High Tech REI2030[4]	Reference TPC[2]	High Tech TPC[2] (%)
Hot Rolling[7]	0.826	0.761	-0.680	-0.973	0.800	0.652	0.337	-0.728	-3.040
Hot Rolling-Steam[7]	0.681	0.761	-1.361	-0.973	0.800	0.531	0.337	-1.456	-3.040
Cold Rolling[7]	0.737	0.706	-1.084	-1.236	0.924	0.474	0.400	-2.356	-2.946
Cold Rolling-Steam[7]	0.541	0.706	-2.168	-1.236	0.924	0.239	0.400	-4.712	-2.946
Aluminum									
Alumina Refining	0.930	0.915	-0.260	-0.317	0.900	0.860	0.576	-0.164	-1.580
Alumina Refining-Steam	0.864	0.800	-0.519	-0.794	0.900	0.821	0.494	-0.328	-2.117
Primary Smelting	0.900	0.800	-0.376	-0.794	0.950	0.800	0.522	-0.612	-2.117
Primary Smelting-Steam	0.810	0.800	-0.751	-0.794	0.950	0.673	0.522	-1.224	-2.117
Secondary	0.875	0.825	-0.476	-0.685	0.850	0.750	0.376	-0.446	-2.869
Semi-Fabrication, Sheet	0.900	0.750	-0.376	-1.022	0.900	0.800	0.457	-0.420	-2.389
Semi-Fabrication, Other	0.925	0.825	-0.278	-0.685	0.950	0.850	0.467	-0.396	-2.505
Metal-Based Durables									
Fabricated Metals									
Process Heating	0.728	0.704	-1.127	-1.245	0.675	0.420	0.380	-1.679	-2.032
Process Cooling-Electricity	0.669	0.647	-1.427	-1.545	0.638	0.385	0.348	-1.784	-2.137
Process Cooling-Natural Gas	0.728	0.704	-1.127	-1.245	0.675	0.420	0.380	-1.679	-2.032
Other	0.728	0.704	-1.127	-1.245	0.675	0.420	0.380	-1.679	-2.032
Other-Electricity	0.763	0.738	-0.962	-1.080	0.686	0.420	0.380	-1737	-2.091
Machinery									
Process Heating	0.728	0.704	-1.127	-1.245	0.675	0.330	0.284	-2.519	-3.048
Process Cooling-Electricity	0.669	0.647	-1.427	-1.545	0.638	0.298	0.256	-2.676	-3.206
Process Cooling-Natural Gas	0.728	0.704	-1.127	-1.245	0.675	0.330	0.284	-2.519	-3.048
Other	0.728	0.704	-1.127	-1.245	0.675	0.330	0.284	-2.519	-3.048
Other-Electricity	0.763	0.738	-0.962	-1.080	0.686	0.328	0.281	-2.606	-3.136
Computers and Electronics									
Process Heating	0.810	0.792	-0.751	0.830	0.720	0.569	0.541	-0.840	-1.016
Process Cooling-Electricity	0.765	0.748	-0.952	1.030	0.680	0.529	0.503	-0.892	-1.069
Process Cooling-Natural Gas	0.810	0.792	-0.751	0.830	0.720	0.569	0.541	-0.840	-1.016
Other	0.810	0.792	-0.751	0.830	0.720	0.569	0.541	-0.840	-1.016
Other-Electricity	0.835	0.817	-0.641	0.720	0.732	0.573	0.545	-0.869	-1.045
Electrical Equipment									
Process Heating	0.810	0.792	-0.751	0.830	0.720	0.569	0.541	-0.840	-1.016
Process Heating-Steam	0.655	0.626	-1.502	-1.660	0.720	0.448	0.405	-1.679	-2.032
Process Cooling-Electricity	0.765	0.748	-0.952	-1.030	0.680	0.529	0.503	-0.892	-1.069
Processing Cooling-Natural Gas	0.810	0.792	-0.751	-0.830	0.720	0.569	0.541	-0.840	-1.016
Other	0.810	0.792	-0.751	-0.830	0.720	0.569	0.541	-0.840	-1.016
Other-Electricity	0.835	0.817	-0.641	-0.720	0.732	0.573	0.545	-0.869	-1.045
Transportation Equipment									
Process Heating	0.863	0.849	-0.526	-0.581	0.765	0.633	0.609	-0.672	-0.813
Process Heating-Steam	0.744	0.721	-1.052	-1.162	0.765	0.524	0.483	-1.343	-1.626
Process Cooling-Electricity	0.829	0.817	-0.666	-0.721	0.723	0.591	0.568	-0.714	-0.855
Process Cooling-Natural Gas	0.863	0.849	-0.526	-0.581	0.765	0.633	0.609	-0.672	-0.813
Other	0.863	0.849	-0.526	-0.581	0.765	0.633	0.609	-0.672	-0.813
Other-Electricity	0.882	0.868	-0.449	-0.504	0.778	0.640	0.615	-0.695	-0.836

Table 6.3. Coefficients for Technology Possibility Curve for all Industrial Scenarios (applies to all fuels unless specified) (continued)

	Existing Facilities				New Facilities				
Industry/Process Unit	Reference REI 2030[1]	Reference REI 2030[1]	High Tech REI20301[1]	Reference TPC[2] (%)	REI 2002[3]	Reference REI2030[4]	High Tech REI2030[4]	Reference TPC[2]	High Tech TPC[2] (%)
Other Non-Intensive Manufacturing									
Wood Products									
Process Heating	0.728	0.705	-1.127	-1.241	0.630	0.392	0.356	-1.679	-2.021
Process Heating-Steam	0.528	0.495	-2.253	-2.481	0.630	0.242	0.198	-3.358	-4.041
Process Cooling-Electricity	0.669	0.647	-1.427	-1.541	0.595	0.359	0.326	-1.784	-2.126
Process Cooling-Natural Gas	0.728	0.705	-1.127	-1.241	0.630	0.392	0.356	-1.679	-2.021
Other	0.728	0.701	-1.127	-1.260	0.630	0.392	0.357	-1.679	-2.009
Other-Electricity	0.763	0.661	-0.962	-1.469	0.641	0.392	0.352	-1.737	-2.112
Plastic Products									
Process Heating	0.810	0.793	-0.751	-0.827	0.675	0.533	0.508	-0.840	-1.010
Process Heating-Steam	0.655	0.627	-1.502	-1.654	0.675	0.420	0.381	-1.679	-2.021
Process Cooling-Electricity	0.765	0.749	-0.952	-1.027	0.638	0.496	0.473	-0.892	-1.063
Process Cooling-Natural Gas	0.810	0.793	-0.751	-0.827	0.675	0.533	0.508	-0.840	-1.010
Other	0.810	0.790	-0.751	-0.840	0.675	0.533	0.509	-0.840	-1.005
Other-Electricity	0.835	0.759	-0.641	-0.980	0.686	0.538	0.510	-0.869	-1.056
Balance of Manufacturing									
Process Heating	0.690	0.665	-1.315	-1.447	0.675	0.373	0.330	-2.099	-2.526
Process Heating-Steam	0.474	0.439	-2.629	-2.895	0.675	0.203	0.158	-4.198	-5.052
Process Cooling-Electricity	0.625	0.602	-1.665	-1.798	0.638	0.339	0.300	-2.230	-2.657
Process Cooling-Natural Gas	0.690	0.665	-1.315	-1.447	0.675	0.373	0.330	-2.099	-2.526
Other-Natural Gas	0.690	0.661	-1.315	-1.470	0.675	0.373	0.331	-2.099	-2.511

[1]REI 2030 Existing Facilities = Ratio of 2030 energy intensity to average 2002 energy intensity for existing facilities.

[2]TPC = annual rate of change between 2002 and 2030.

[3]REI 2002 New Facilities = For new facilities, the ratio of state-of-the-art energy intensity to average 2002 energy intensity for existing facilities.

[4]REI 2030 New Facilities = Ratio of 2030 energy intensity for a new state-of-the-art facility to the average 2002 intensity for existing facilities.

[5]REI's and TPCs apply to virgin and recycled materials.

[6]No new plants are likely to be built with these technologies.

[7]Net shape casting is projected to reduce the energy requirements for hot and cold rolling rather than for the continuous casting step.

NA = Not applicable.

BF = Blast furnace.

BOF = Basic oxygen furnace.

EAF = Electric arc furnace.

Source: Energy Information Administration, *Model Documentation Report*, *Industrial Sector Demand Module of the National Energy Modeling System*, DOE/EIA-M064(2008) (Washington, DC, 2008).

Table 6.4. Cost and Performance Parameters for Industrial Motor Choice Model

Industrial Sector Horsepower Range	2002 Stock Efficiency (%)	Premium Efficiency (%)	Premium Cost (2002$)
Food			
1 - 5 hp	81.3	89.2	607
6 - 20 hp	87.1	92.5	1,352
21 - 50 hp	90.1	93.8	2,612
51 - 100 hp	92.7	95.3	6,354
101 - 200 hp	93.5	95.2	11,548
201 - 500 hp	93.8	95.4	30,299
> 500 hp	93.0	96.2	36,187
Bulk Chemicals			
1 - 5 hp	82.0	89.4	607
6 - 20 hp	87.4	92.6	1,352
21 - 50 hp	90.4	93.9	2,612
51 - 100 hp	92.4	95.4	6,354
101 - 200 hp	93.5	95.3	11,548
201 - 500 hp	93.3	95.5	30,299
> 500 hp	93.2	96.2	36,187
Metal-Based Durables[1]			
1 - 5 hp	81.9	89.2	607
6 - 20 hp	89.9	92.5	1,352
21 - 50 hp	89.9	93.9	2,612
51 - 100 hp	92.0	95.3	6,354
101 - 200 hp	93.5	95.2	11,548
201 - 500 hp	93.7	95.4	30,299
> 500 hp	93.0	96.2	36,187
Other Non-Intensive Manufacturing[2]			
1 - 5 hp	83.0	89.2	607
6 - 20 hp	88.3	92.5	1,352
21 - 50 hp	90.3	93.9	2,612
51 - 100 hp	92.7	95.3	6,354
101 - 200 hp	94.3	95.2	11,548
201 - 500 hp	94.3	95.4	30,299
> 500 hp	92.9	96.2	36,187

[1] The Metal-Based Durables group includes five sectors that are modeled separately: Fabricated Metal Products; Machinery; Computer and Electronic Products; Electrical Equipment, Appliances, and Components; and Transportation Equipment

[2] The Other Non-Intensive Manufacturing group includes three sectors that are modeled separately: Wood Products; Plastics and Rubber Products; and Balance of Manufacturing.

Source: Energy Information Administration, *Model Documentation Report, Industrial Sector Demand Module of the National Energy Modeling System*, DOE/EIA-M064(2008) (Washington, DC, 2008).

Note: The efficiencies listed in this table are operating efficiencies based on average part-loads. Because the average part-load is not the same for all industries, the listed efficiencies for the different motor sizes vary across industries.

Buildings Component

The total buildings energy demand by industry for each region is a function of regional industrial employment and output. Building energy consumption was estimated for building lighting, HVAC (heating,ventilation, and air conditioning), facility support, and onsite transportation. Space heating was further divided to estimate the amount provided by direct combustion of fossil fuels and that provided by steam (Table 6.5). Energy consumption in the BLD Component for an industry is estimated based on regional employment and output growth for that industry.

Boiler/Steam/Combined Heat and Power Component

The steam demand and byproducts from the PA and BLD Components are passed to the BSC Component, which applies a heat rate and a fuel share equation (Table 6.6) to the boiler steam requirements to compute the required energy consumption.

The boiler fuel shares apply only to the fuels that are used in boilers for steam-only applications. Fuel shares for the portion of the steam demand associated with combined heat and power (CHP) is assumed fixed. Some fuel switching for the remainder of the boiler fuel use is assumed and is calculated with a logit sharing equation where fuels shares are a function of fuel prices. The equation is calibrated to 2002 so that the 2002 fuel shares are produced for the relative prices that prevailed in 2002.

The byproduct fuels, production of which are estimated in the PA Component, are assumed to be consumed without regard to price, independent of purchased fuels. The boiler fuel share equations and calculations are based on the 2002 MECS.

Combined Heat and Power

CHP plants, which are designed to produce both electricity and useful heat, have been used in the industrial sector for many years. The CHP estimates in the module are based on the assumption that the historical relationship between industrial steam demand and CHP will continue in the future, and that the rate of additional CHP penetration will depend on the economics of retrofitting CHP plants to replace steam generated from existing non-CHP boilers. The technical potential for CHP is primarily based on supplying thermal requirements. Capacity additions are then determined by the interaction of payback periods CHP retrofit investment and market penetration rates for investments with given payback periods. Assumed installed costs for the CHP systems are given in Table 6.7.

Table 6.5. 2002 Building Component Energy Consumption (Trillion Btu)

		Building Use and Energy Source					
Industry	Region	Lighting Electricity Consumption	HVAC Electricity Consumption	HVAC Natural Gas Consumption	HVAC Steam Consumption	Facility Support Total Consumptiion	Onsite Transportation Total Consumption
Food Products	1	1.6	1.7	4.0	2.0	1.0	0.9
	2	7.2	7.7	16.9	4.4	1.2	3.5
	3	5.8	6.2	12.1	6.0	2.1	2.7
	4	2.5	2.7	7.5	3.7	1.8	1.5
Paper & Allied Products	1	1.9	2.0	3.6	0.0	0.9	0.5
	2	3.5	3.7	6.4	0.0	1.2	0.9
	3	7.1	7.5	14.0	0.0	2.6	1.8
	4	2.9	3.1	3.4	0.0	0.7	0.7
Bulk Chemicals	1	1.4	1.7	1.3	0.0	0.8	0.6
	2	3.1	3.7	2.3	0.0	1.0	1.2
	3	13.0	15.7	16.4	0.0	6.2	6.3
	4	0.9	1.1	1.1	0.0	0.2	0.4
Glass & Glass Products	1	0.3	0.5	2.2	0.0	0.5	0.5
	2	0.6	0.9	2.1	0.0	0.1	0.1
	3	0.8	1.3	3.3	0.0	0.8	0.9
	4	0.2	0.4	0.9	0.0	0.1	0.1
Cement	1	0.1	0.1	0.1	0.0	0.7	0.1
	2	0.2	0.2	0.4	0.0	1.5	0.2
	3	0.4	0.4	0.6	0.0	1.5	0.3
	4	0.2	0.2	0.3	0.0	1.4	0.1
Iron & Steel	1	0.6	0.7	3.4	0.0	0.8	0.6
	2	2.1	2.6	8.1	0.0	6.5	1.6
	3	2.0	2.5	3.2	0.0	0.9	0.9
	4	0.4	0.4	0.3	0.0	0.0	0.1
Aluminum	1	0.3	0.4	0.7	0.0	0.1	0.2
	2	0.8	1.1	1.6	0.0	0.1	0.6
	3	1.5	2.1	3.7	0.0	1.2	1.2
	4	0.3	0.4	6.5	0.0	0.0	0.2
Metal-Based Durables							
Fabricated Metal Products	1	2.2	2.4	7.4	2.1	0.2	0.7
	2	7.3	7.8	25.1	7.1	1.0	2.1
	3	5.2	5.6	15.2	4.3	1.4	1.5
	4	1.4	1.5	3.4	1.0	0.0	0.4
Machinery	1	1.9	2.6	4.7	2.4	0.1	0.5
	2	5.8	7.7	18.7	9.4	0.8	1.7
	3	3.7	5.0	6.9	3.5	0.4	0.9
	4	1.0	1.4	2.3	1.2	0.0	0.3
Computers & Electronic Products	1	5.2	11.3	7.1	8.9	0.2	3.1
	2	2.5	5.3	4.1	5.1	0.2	1.6
	3	4.2	9.2	2.7	3.3	0.1	2.4
	4	5.9	12.8	8.0	10.0	0.2	3.5

Table 6.5. 2002 Building Component Energy Consumption (cont.)
(Trillion Btu)

Industry	Region	Lighting Electricity Consumption	Building Use and Energy Source: HVAC Electricity Consumption	Building Use and Energy Source: HVAC Natural Gas Consumption	Building Use and Energy Source: HVAC Steam Consumption	Facility Support Total Consumptiion	Onsite Transportation Total Consumption
Electrical Equipment	1	0.9	1.2	3.0	1.3	0.1	0.2
	2	2.3	3.0	5.7	2.4	0.2	0.5
	3	2.8	3.7	5.5	2.3	0.9	0.6
	4	0.4	0.5	1.6	0.7	0.1	0.2
Transportation Equipment	1	2.2	2.8	6.6	0.9	0.1	0.7
	2	14.7	18.6	36.9	5.2	1.6	4.7
	3	7.5	9.5	14.5	2.0	1.1	2.3
	4	2.5	3.2	5.8	0.8	0.1	0.8
Other Non-Intensive Manufacturing							
Wood Products	1	0.3	0.3	0.7	1.1	1.7	0.3
	2	0.8	0.8	2.1	3.3	1.3	0.4
	3	2.9	2.9	3.7	5.8	4.0	1.2
	4	1.3	1.3	2.2	3.5	2.6	0.6
Plastic Products	1	2.1	2.6	3.1	0.0	0.9	0.8
	2	5.5	6.7	10.0	0.0	1.0	2.1
	3	6.0	7.3	12.4	0.0	1.1	2.4
	4	1.2	1.5	1.8	0.0	0.0	0.4
Balance of Manufacturing	1	6.9	9.7	7.0	0.0	1.6	2.1
	2	16.0	22.4	31.3	0.0	2.0	6.2
	3	26.2	36.8	62.4	0.0	2.9	11.3
	4	7.8	10.9	16.7	0.0	3.5	3.1

HVAC = Heating, Ventilation, Air Conditioning.

Source: Energy Information Administration, *Model Documentation Report: Industrial Demand Module of the National Energy Modeling System*, DOE/EIA-M064(2008), (Washington, DC, 2008).

Table 6.6. 2002 Boiler Fuel Consumption and Logit Parameter
(trillion Btu)

Industry	Region	Alpha	Natural Gas	Coal	Oil	Renewables
Food Products	1	-2.0	28	2	5	2
	2	-2.0	125	154	4	15
	3	-2.0	86	10	3	33
	4	-2.0	53	13	4	6
Paper & Allied Products	1	-2.0	56	28	25	87
	2	-2.0	64	75	13	103
	3	-2.0	157	97	61	864
	4	-2.0	48	14	4	164
Bulk Chemicals	1	-2.0	43	3	56	0
	2	-2.0	98	34	46	0
	3	-2.0	685	194	271	0
	4	-2.0	50	1	3	0
Glass & Glass Products	1	-2.0	0	0	6	2
	2	-2.0	1	0	0	1
	3	-2.0	1	0	9	1
	4	-2.0	0	0	0	0
Cement	1	-2.0	0	1	0	0
	2	-2.0	0	2	0	0
	3	-2.0	0	3	0	0
	4	-2.0	0	2	0	0
Iron & Steel	1	-2.0	10	7	4	0
	2	-2.0	24	1	67	0
	3	-2.0	9	0	22	0
	4	-2.0	1	0	10	0
Aluminum	1	-2.0	2	0	0	1
	2	-2.0	5	0	0	0
	3	-2.0	10	0	0	8
	4	-2.0	2	0	0	0
Fabricated Metal Products	1	-2.0	2	0	0	2
	2	-2.0	7	0	1	2
	3	-2.0	5	0	0	0
	4	-2.0	1	0	0	0
Machinery	1	-2.0	2	0	0	1
	2	-2.0	9	1	0	1
	3	-2.0	3	0	0	0
	4	-2.0	1	0	0	0

Table 6.6. 2002 Boiler Fuel Consumption and Logit Parameter (cont.)
(trillion Btu)

Industry	Region	Alpha	Natural Gas	Coal	Oil	Renewables
Computers and Electronic Products	1	-2.0	10	0	2	0
	2	-2.0	5	0	0	0
	3	-2.0	4	0	0	0
	4	-2.0	11	0	0	0
Electrical Equipment	1	-2.0	1	0	0	0
	2	-2.0	2	0	0	0
	3	-2.0	2	0	0	0
	4	-2.0	1	0	0	0
Transportation Equipment	1	-2.0	5	8	3	8
	2	-2.0	31	0	1	11
	3	-2.0	12	2	2	2
	4	-2.0	5	0	0	1
Wood Products	1	-2.0	1	0	0	11
	2	-2.0	4	0	0	20
	3	-2.0	7	1	1	142
	4	-2.0	4	0	0	56
Plastic Products	1	-2.0	6	2	2	1
	2	-2.0	21	20	1	1
	3	-2.0	24	0	4	2
	4	-2.0	4	0	0	0
Balance of Manufacturing	1	-2.0	15	9	43	8
	2	-2.0	68	50	16	3
	3	-2.0	137	54	54	7
	4	-2.0	35	7	1	2

Alpha: User-specified.

Source: Energy Information Administration, *Model Documentation Report: Industrial Sector Demand Module of the National Energy Modeling System*, DOE/EIA-064(2008), (Washington, DC, 2008).

Table 6.7. Cost Characteristics of Industrial CHP Systems

		Installed Cos($2005 per kilowatt)[1]		
	Size	Reference	Reference	High Tech
System	(kilowatts)	2005	2030	2030
Engine	1000	1373	989	927
	3000	1089	929	918
Gas Turbine	3000	1530	1265	1036
	5000	1180	979	903
	10000	1104	959	895
	25000	930	813	779
	40000	808	743	723
Combined Cycle	100000	846	787	768

[1]Costs are given in 2005 dollars in original source document.

Source: Energy Information Administration, *Model Documentation Report: Industrial Sector Demand Module of the National Energy Modeling System,* DOE/EIA-MO64(2008) (Washington, DC, 2008).

Legislation and Regulations

Energy Improvement and Extension Act of 2008

Under EIEA2008 Title I, “Energy Production Incentives,” Section 103 provides an Investment Tax Credit (ITC) for qualifying Combined Heat and Power (CHP) systems placed in service before January 1, 2017. Systems with up to 15 megawatts of electrical capacity qualify for an ITC up to 10 percent of the installed cost. For systems between 15 and 50 megawatts, the percentage tax credit declines linearly with the capacity, from 10 percent to 3 percent. To qualify, systems must exceed 60-percent fuel efficiency, with a minimum of 20 percent each for useful thermal and electrical energy produced. The provision was modeled in *AEO2009* by adjusting the assumed capital cost of industrial CHP systems to reflect the applicable credit.

The Energy Independence and Security Act of 2007

Under EISA2007, the motor efficiency standards established under the Energy Policy Act of 1992 (EPACT) are superseded for purchases made after 2011. Section 313 of EISA2007 increases or creates minimum efficiency standards for newly manufactured, general purpose electric motors. The efficiency standards are raised for general purpose, integral-horsepower induction motors with the exception of fire pump motors. Minimum standards were created for seven types of poly-phase, integral-horsepower induction motors and NEMA design “B” motors (201-500 horsepower) that were not previously covered by EPACT standards. The industrial module’s motor efficiency assumptions reflect the EISA2007 efficiency standards for new motors added after 2011.

Energy Policy Act of 1992 (EPACT)

EPACT contains several implications for the industrial module. These implications concern efficiency standards for boilers, furnaces, and electric motors. The industrial module uses heat rates of 1.25 (80 percent efficiency) and 1.22 (82 percent efficiency) for gas and oil burners, respectively. These efficiencies meet the EPACT standards. EPACT mandates minimum efficiencies for all motors up to 200 horsepower purchased after 1998. The choices offered in the motor efficiency assumptions are all at least as efficient as the EPACT minimums.

Clean Air Act Amendments of 1990 (CAAA90)

The CAAA90 contains numerous provisions that affect industrial facilities. Three major categories of such provisions are as follows: process emissions, emissions related to hazardous or toxic substances, and SO2 emissions.

Process emissions requirements were specified for numerous industries and/or activities (40 CFR 60). Similarly, 40 CFR 63 requires limitations on almost 200 specific hazardous or toxic substances. These specific requirements are not explicitly represented in the NEMS industrial model because they are not directly related to energy consumption projections.

Section 406 of the CAAA90 requires the Environmental Protection Agency (EPA) to regulate industrial SO_2 emissions at such time that total industrial SO_2 emissions exceed 5.6 million tons per year (42 USC 7651). Since industrial coal use, the main source of SO_2 emissions, has been declining, EPA does not anticipate that specific industrial SO_2 regulations will be required (Environmental Protection Agency, National Air Pollutant Emission Trends: 1990-1998, EPA-454/R-00-002, March 2000, Chapter 4). Further, since industrial coal use is not projected to increase, the industrial cap is not expected be a factor in industrial energy consumption projections. (Emissions due to coal-to-liquids CHP plants are included with the electric power sector because they are subject to the separate emission limits of large electricity generating plants.)

Industrial Alternative Cases

Technology Cases

The *high technology case* assumes earlier availability, lower costs, and higher efficiency for more advanced equipment, based on engineering judgments and research compiled by Focis Associates in a 2005 study for EIA (Tables 6.3 and 6.7).[4] The *high technology case* also assumes that the rate at which biomass byproducts will be recovered from industrial processes increases from 0.1 percent per year to 0.7 percent per year. The availability of additional biomass leads to an increase in biomass-based cogeneration. Changes in aggregate energy intensity result both from changing equipment and production efficiency and from changes in the composition of industrial output. Since the composition of industrial output remains the same as in the reference case, delivered energy intensity declines by 1.7 percent annually compared with the reference case, in which delivered energy intensity is projected to decline 1.5 percent annually.

The *2009 technology case* holds the energy efficiency of plant and equipment constant at the 2009 level over the projection. Both cases were run with only the Industrial Demand Module rather than as a fully integrated NEMS run, (i.e., the other demand models and the supply models of NEMS were not executed). Consequently, no potential feedback effects from energy market interactions were captured.

AEO2009 also includes an integrated high technology case (*consumption high technology*), which combines the *high technology cases* of the four end-use demand sectors, the electricity *high fossil technology case*, the *advanced nuclear case*, and the *high renewables case*.

The *high renewable case* assumes that the rate at which biomass byproducts will be recovered from industrial processes increases from 0.1 percent per year to 0.7 percent per year. The availability of additional biomass leads to an increase in biomass-based CHP.

Notes and Sources

[1] Energy Information Administration, State Energy Data System, based on energy consumption by state through 2005, as downloaded in July, 2008, from www.eia.doe.gov/emeu/states/_seds.html.

[2] Energy Information Administration, Manufacturing Energy Consumption Survey, web site www.eia.doe.gov/emeu/mecs/mecs2002/data02/shelltables.html.

[3] U.S., Department of Energy(2005). Motor Master+ 4.0 software database; available online: http://www1.eere.energy.gov/industry/bestpractices/software.html#mm.

[4] Energy Information Administration, Industrial Technology and Data Analysis Supporting the NEMS Industrial Model (Focis Associates, October 2005).

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